بسم اللّه الرحمن الرحيم

عنوان المحاضرة: Urologic investigations
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Methods: 1-Lab 2-Imaging 3-Instrumentation 4-Urodynamic studies

A) LABORATORY:

I. Urine analysis:

-Methods of collection:

▪*Males* → Midstream Sample (in circumcised males)

▪*Females* →Segmented Voided Urine Specimens (should spread the labia & wipe the periurethral area)
-Urethral Catheterization (in infections)

▪*Neonates & Infants* → Suprapubic Aspiration (MCQ) under complete aseptic conditions

-In chronic prostatitis → Four aliquots of urine: (VB1, VB2, EPS, VB3)

▪*Voided Bladder 1:* first 5-10 mL of voided urine, represents urethral flora

▪*Voided Bladder 2:* midstream urine, best correlates with bladder urine

▪*Expressed Prostatic Secretions:* collected following prostatic massage

▪*Voided Bladder 3:* initial 2-3 mL of urine collected following prostatic massage

-All urine samples should be examined within one hour of collection as after 1 hour (change of pH, bacterial overgrowth, and disintegration of RBCs & WBCs)

-1st morning urine specimen is the best for microscopy

-Urine dipsticks: small marker pads impregnated with chemicals that react with the compounds in urine

1-Color: (EXAM Q)

-The normal pale yellow color of urine is due to the presence of the pigment urochrome

-Urine color varies most commonly because of concentration

-Foods, medications, metabolic products, and infection may produce abnormal urine color

Colorless	Very dilute urine - Overhydration
Cloudy/milky	Phosphaturia - Pyuria - Chyluria
Red	Hematuria - Hemoglobinuria/myoglobinuria - Anthrocyanin in beets and blackberries - Chronic lead and mercury poisoning - Phenolphthalein (in bowel evacuants) - Phenothiazines (e.g., Compazine) - Rifampin
Orange	Dehydration - Phenazopyridine (Pyridium) - Sulfasalazine (Azulfidine)
Yellow	Normal - Phenacetin - Riboflavin
Green-blue	Biliverdin - Indicanuria (tryptophan indole metabolites) - Amitriptyline (Elavil) - Indigo carmine - Methylene blue - Phenois (e.g., IV cimetidine [Tagamet], - IV promethazine [Phenergan]) - Resorcinol - Triamterene (Dyrenium)
Brown	Urobilinogen - Porphyria - Aloe, fava beans, and rhubarb - Chloroquine and primaquine - Furazolidone (Furoxone) - Metronidazole (Flagyl) - Nitrofurantoin (Furadantin)
Brown-black	Alcaptonuria (homogentisic acid) - Hemorrhage - Melanin - Tyrosinosis (hydroxyphenylpyruvic acid) - Cascara, senna (laxatives) - Methocarbamol (Robaxin) - Methyldopa (Aldomet) - Sorbitol

2-Turbidity:

-Cloudy urine is most commonly due to phosphaturia

-The large numbers of white blood cells cause the urine to become turbid.

-Pyuria is readily distinguished from phosphaturia either by smelling the urine (infected urine has a characteristic pungent odor)

-Rare causes of cloudy urine include chyluria, lipiduria, hyperoxaluria, and hyperuricosuria.

3-Specific gravity:

-Specific gravity of urine is determined from a urinary dipstick and usually varies from 1.001 to 1.035.

-A specific gravity **less than 1.008** is regarded as dilute, and a specific gravity **greater than 1.020** is considered concentrated.

Causes that decrease the specific gravity:

1-Increased fluid intake   2-Diuretics   3-Decreased renal concentrating ability   4-Diabetes insipidus

Causes that increase the specific gravity:

1-Decreased fluid intake   2-Dehydration owing to fever, sweating, vomiting, and diarrhea

3-Diabetes mellitus (glucosuria)   4-Inappropriate secretion of antidiuretic hormone

4-pH:

▪Urinary pH may vary from 4.5 to 8   ▪The average pH varies between 5.5 and 6.5

▪pH between 4.5 and 5.5 is considered **acidic**   ▪pH between 6.5 and 8 is considered **alkaline**

-In patients with a presumed UTI, an alkaline urine with a pH greater than 7.5 suggests infection with a **urea-splitting** organism, most commonly Proteus.

-Urinary pH is usually **acidic** in patients with uric acid and cystine lithiasis.

-Urinary pH reflects the serum pH except in the case of **renal tubular acidosis type 1**

5-Glucose:

-Normally: all glucose is filtered then reabsorbed in the PCT

-**Serum glucose > 180 mg/dL** (Renal threshold)→ glucose will be detected in the urine

-Useful in screening patients for diabetes mellitus

6-Keton bodies:

-Not normally found in the urine but will appear when the carbohydrate supplies in the body are depleted and body fat breakdown occurs

-Ketones excreted include acetoacetic acid, acetone, and β-hydroxybutyric acid. With abnormal fat breakdown, ketones will appear in the urine before the serum

-May be found normally during pregnancy

7-Bilirubin and Urobilinogen:

-Normal urine contains **no bilirubin** and only very small amounts of urobilinogen

-Conjugated bilirubin has a low molecular weight, is water soluble, and normally passes from the liver into the small intestine through the bile ducts, where it is converted to urobilinogen

-Therefore, **conjugated bilirubin** does not appear in the urine except in pathologic conditions in which there is intrinsic hepatic disease or obstruction of the bile ducts

-**Indirect bilirubin** is of high molecular weight and bound in the serum to albumin. It is water insoluble and, therefore, **does not appear** in the urine even in pathologic conditions

-Urobilinogen is the end product of conjugated bilirubin metabolism

8-Protein:

-Healthy adults excrete **80 to 150 mg** of protein in the urine daily

-Proteinuria may be the first indication of renovascular, glomerular, or tubulointerstitial renal disease, or it may represent the overflow of abnormal proteins into the urine in conditions such as multiple myeloma.

-Normally, urine protein is about 30% albumin, 30% serum globulins, and 40% tissue proteins, of which the major component is Tamm-Horsfall protein.

Evaluation of proteinuria:

A) Transient: d.t. (exercise, emotional stress, fever) → repeat urinalysis

  -Normal → no further evaluation   -Abnormal → evaluate for persistent proteinuria

B) Intermittent: -Related to upright position → orthostatic proteinuria

  -Not related to position → evaluate for persistent proteinuria

C) Persistent: 24 hour urine protein + qualitative evaluation

1- *>2000 mg/ 24 hr & primarily albumin*

- With hematuria → Glomerular hematuria
- Without hematuria → further evaluation for DM, amyloidosis, nephrocalcinosis

2- *300:2000 mg/24 hr & primarily globulin*

Outflow proteinuria → evaluate for multiple myloma, hemoglobinuria, myoglobinuria

9-Leukocyte Esterase and Nitrite Tests

-Leukocyte esterase activity indicates the presence of white blood cells in the urine.

-The presence of nitrites in the urine is strongly suggestive of bacteriuria

-Nitrites are not normally found in the urine, but many species of gram-negative bacteria can convert nitrates to nitrites

10-Hematuria: (EXAM Q)

-Normal urine should contain less than three red blood cells per HPF

	Glomerular hematuria	Non glomerular hematuria	
		Medical	Surgical
Erythrocytes	Dysmorphic	Circular	
Proteinuria	+++	+++	---
Causes	-IgA nephropathy -Glomerulonephritis -SLE -Bacterial endocarditis	-UTI -Tuberculosis -Schistosomiasis -Drugs -Blood dyscrasias -Exercise-induced	-TCC of bladder, ureter, renal pelvis -RCC -Stone -Trauma -BPH -Urethral stricture

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Microscopy:

-Low-power magnification:

Sufficient to identify erythrocytes, leukocytes, casts, cystine crystals, oval fat macrophages, and parasites such as Trichomonas vaginalis and Schistosoma hematobium.

-High-power magnification:

Necessary to distinguish circular from dysmorphic erythrocytes, to identify other types of crystals, and, particularly, to identify bacteria and yeast

-The urinary sediment should be examined microscopically for:

(1) Cells (2) Casts (3) Crystals (4) Bacteria (5) Yeast (6) Parasites

1-Cells: RBCs (hematuria) - WBCs (infection) - Epithelial cells (nephrotic syndrome)

2-Casts: Hyaline - RBCs - Cystine

3-Crystals: Cystine - Uric acid - Ca oxalate - Triple phosphate - Ca carbonate - Indinavir (not appear in CT)

4-Bacteruria: 5 bacteria /HPF reflects colony counts of about 1×10^5 CFU/mL

5-Yeast: most commonly Candida albicans, with DM or in women with vaginal candidiasis.

6-Parasites: e.g. Trichomonas vaginalis

II. Renal Function Test:

1-Specific Gravity: -Low specific gravity indicates losing of concentrating power of kidney

2-Blood Urea Nitrogen (BUN):

-Affected by dietary intake, hydration status, GIT bleeding

-Normal adult BUN → 8-25 mg/dL -Normal adult blood urea → 20-40 mg/dL

-Approximately 2/3 of renal function must be lost before significance rise in BUN

-BUN/creatinine ratio: normally 10:1, decrease in over-hydration & hepatic insufficiency

3-Serum creatinine:

-Excreted only by kidney -Normally: Adult → 0.8-1.2 mg/dL Children → 0.4-0.8 mg/dL

-Still normal till 50% of kidney function is lost -Not affected by diet

4-Creatinine Clearance:

-Most accurate -Requires collection of 24 hr urine specimen

-Creatinine clearance = $\frac{UxV}{P}$ (U →urine creatinine, V→ urine volume, P → plasma creatinine)

-Normally 90 -110 mL/ min

III. Blood, Serum & Plasma:

1-CBC:-Normocytic normochromic anemia → chronic renal insufficiency
-RBCs → paraneoplastic syndrome -WBCs → Leukemia

2-Clotting studies: -Preoperative -Unexplained hematuria

3-Electrolytes: -Serum Ca, Na, K (following TURP to avoid dilutional hyponatremia “TURP syndrome”)

4-Enzymes: -Serum acid phosphatase -PSA (normal up to 4.0 ng/mL) -Serum alkaline phosphatase

5-Hormonal studies:

-Serum PTH → parathyroid adenoma -Serum renin → Renovascular Hypertension
-Adrenal steroid hormones -Serum testosterone → impotence, infertility

6-Others: -Fasting plasma glucose -Serum uric acid -Liver function tests

IV. Imaging:

1-Plain x-ray:

Indications:

1-Renal complaints: ▪Acute: Renal colic ▪Chronic: dull aching renal pain
2-Urine changes: ▪Gross: hematuria - pyuria ▪Microscopic: heavy crystalluria
3-Urine cessation: anuria, acute urine retention
4-Preoperative: confirmation of stone & position
5-Intraoperative; localization of calyceal stone sites for rapid, easy & less traumatic extraction
6-Postoperative: follow-up

Contraindications: Pregnancy esp. 1st trimester (teratogenicity)

Preparation: Get rid of intestinal gases for optimal visualization of UT
(Early light dinner, castor oil, fasting in the morning, water enema)

Limitations: 1-Overlying stool / gas 2-Calcification in vein 3-Poorly calcified stones (uric acid)
4-Stones may be obstructed by bones

Causes of radiopaque shadow:

A) Kidney:

1-Renal stones 2-Gall bladder stones 3-Nephrocalcinosis
4-F.B. in stomach, duodenum and colonic flexures
5-Calcified (renal cyst, suprarenal tumor, renal tumor, liver cyst, costal cartilage, T.B., Atheroma)

B) Ureter:

1-Ureteral stones 2-Stones in ectopic kidney 3-Calcified ureteral wall
4-Pseudocalcinosis of the ureter: localized bilharzial calcification: left L4
5-Calcified mesenteric LN 6-Calcified thromobosed pelvic veins = phleboli.

C) Bladder:

1-Vesical stones 2-Calcified bladder wall 3-Calcified seminal vesicles 4-Calcified fibroid
5-F.B. in bladder, ureter, retroperitoneal space or rectum

2-Urography:

-Involves instillation of **contrast** material to better visualize the collecting or lumenal structures of the kidneys, ureters, bladder, and urethra

-This can be done after IV injection or direct instillation into the urinary tract

▪Intravenous urography ▪Cystography
▪Voiding cystourethroography ▪Retrograde urethrography

Contrast Media:

-Consider the risks and benefits associated with a contrast-enhancedimaging study

-Many different types of contrast media have been used

-**Iodine** is the most common in general use as an intravascular radiologic contrast medium (IRCM)

▪Low lipid solubility & low affinity to protein ▪Eliminated within 12 hrs of injection

Adverse Reactions to Intravascular iodine:

a) Minor Reactions

-Nausea, flushing, pruritus, urticaria, headache, and even emesis after injection of IRCM

-Arm pain can also result from venous spasm or infiltration of the media outside the vein

-These reactions are usually **mild** and do not require additional treatment

b) Intermediate Reactions

-Hypotension or bronchospasm occur in 0.5% to 2% of patients

-These are usually transient and do not need treatment

-If necessary, ▪5 mg of chlorphenamine administered orally, IV, or IM;
▪5 mg of diazepam for anxiety ▪100 to 500 mg of hydrocortisone IM or IV
▪or two to three puffs of beta-agonist inhalators for bronchospasm

c) Severe Reactions

Life-threatening reactions occur in approximately with mortality rates of 1/170,000 uses, include:
-Seizure -Laryngeal spasm -Bronchospasm -Pulmonary edema
-Cardiac arrhythmia -Respiratory collapse ▪Cardiac arrest

-Rapid administration of **epinephrine** is the treatment of choice for severe contrast reactions

Premedication Strategies

-No known premedication strategy will eliminate the risk of a severe adverse reaction to IRCM

-The regimens suggested include the use of corticosteroids, antihistamines and ephedrine

Specific Clinical Considerations:

1-Metformin:

-Patients with type II diabetes mellitus on metformin oral biguanide hyperglycemic therapy may have an accumulation of the drug after administering IRCM, resulting in biguanide lactic acidosis presenting with vomiting, diarrhea, and somnolence

-This condition is fatal in approximately 50% of cases

-Biguanide lactic acidosis is rare in patients with normal renal function.

-Consequently, in patients with normal renal function and no known comorbidities, there is no need to discontinue metformin before IRCM use, nor is there a need to check creatinine following the imaging study.

-However, in patients with **renal insufficiency**, metformin should be **discontinued** the day of the study and withheld for **48 hours**. Postprocedure creatinine should be measured at 48 hours and metformin started once kidney function is normal

2-Contrast-Induced Nephropathy:

-A rise in serum creatinine 25% above baseline, or more than 0.5 mg/dL within 3 days following exposure to contrast media, in the absence of an alternative cause.

-High doses of IRCM can impair renal function in some patients for 3 to 5 days

-Risk factors are:
▪Chronic kidney disease ▪Diabetes mellitus ▪Dehydration ▪Congestive heart failure ▪Age
▪Hypertension, low hematocrit ▪Ventricular ejection fraction less than 40

-The most common non–patient-related causes are highosmolar contrast agents, ionic contrast, increased contrast viscosity, and large-contrast volume infusion

a) Intravenous Urography:

-The classic modality of imaging the entire urethelial tract from pyelocalyceal system trhough the ureters and bladder

-Excellent for indentifying small urethelial lesions as well as the severity of obstruction from calculi

-Provides anatomical and qualitative functional information about the kidneys

b) Cystography:

-Permits imaging of an opacified urinary bladder after retrograde instillation of contrast media through a urethral or suprapubic catheter

-Imaging is performed to demonstrate a suspected urine leak, either from traumatic bladder rupture or after bladder surgery

-Can also demonstrate a presence of a fistula between the bladder and vagina or to characterize bladder diverticuli

c) Voiding Cystourethrography:

-Used to evaluate for abnormal anatomy and function of lower urinary tract in both children & adults

-Instillation of contrast media into the bladder through a urethral cahteter is also employed

-After full distention of the bladder, the patient is instructed to void either after removing the catheter or around the catheter

d) Retrograde Urethrography:

-Complete evaluation of the urethra includes both antegrade and retrograde urethrography

-Allows visualization of the anterior male urethra

-Used for evaluating a suspected traumatic urethral injury or urethral stricture

-Can also be useful for diagnosis of a urethral diverticulum in females

3-Ultrasonography:

-Painless & noninvasive method of using high frequency waves to image anatomic structures and provides valuable information regarding renal morphology and perfusion

-Advantages: ▪Availability ▪ Flexibility ▪Lack of ionizing radiation
▪Accurate anatomic information ▪Safe in pregnancy ▪No cost

-Disadvantages: ▪Inferior resolution compared with urography ▪No functional information
▪Certain structures can't be visualized (e.g. non-dilated abd ureter) ▪Depend on operator's experience

4-CT scan:

-Study of choice for the general imaging of the kidney and ureter

-Used to create cross-sectional images of structures in the body. In this procedure, x-rays are taken from many different angles and processed through a computer to produce a three-dimensional (3-D) image

-Uptake of contrast by renal parenchyma during nephrogram phase provides rough estimate of kidney function

-Useful when renal of ureteral malginancy is suspected

5-MRI

-Can be generally used in place of a CT scan when renal insufficiency or contrast allergy prohibits the use of CT scan

V. Urodynamics:

-A diagnostic tool for the identification and measurement of physiologic and pathologic parameters involved in storage, transportation and evacuation of urine

-The goal of urodynamic testing is to identify and quantitate the causative factors that contribute to voiding dysfunction, whether it is the problem of storage or emptying

-Important in evaluation of patients with voiding dysfunction, urinary incontinence and neuropathic bladder

-The most common studies are: Uroflowmetry, Cystometry, urethral pressure profile and electromyography